The Upgraded D0 Silicon Microstrip Tracker For Fermilab Run2b

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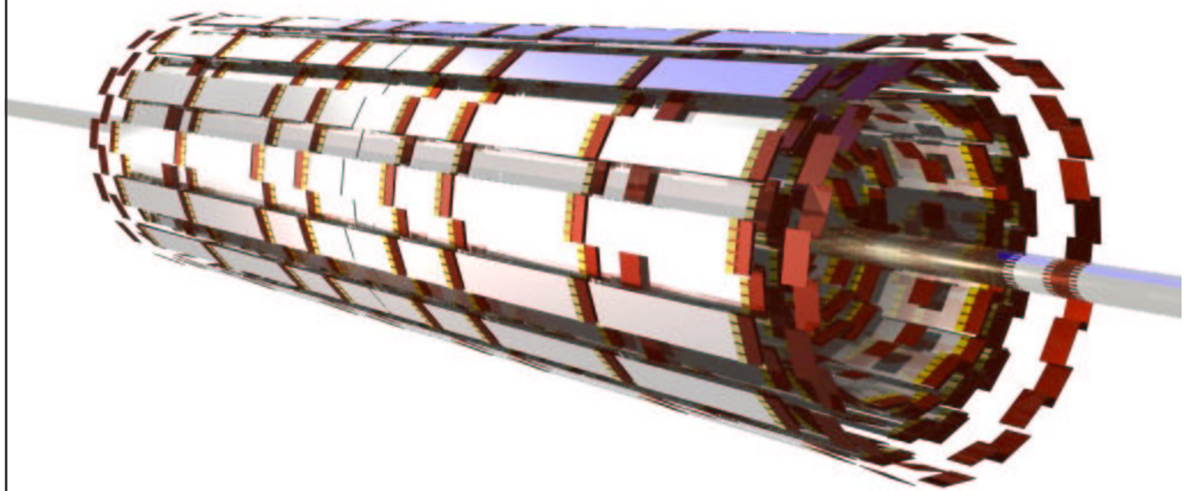
For the D0 collaboration

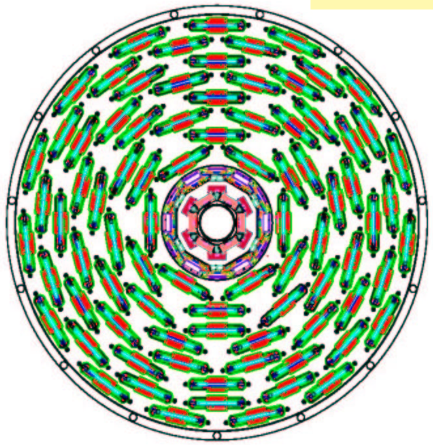


Why a new silicon detector?

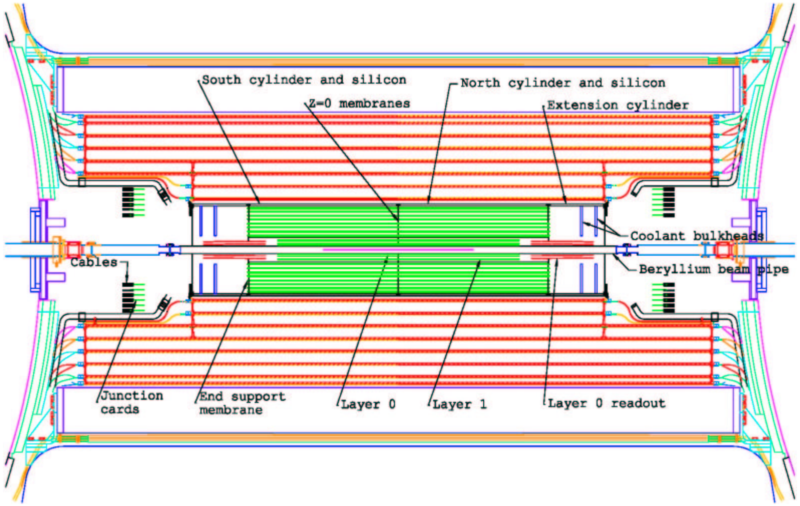
- Extended running at higher luminosity is now foreseen at Fermilab. The current detector was designed for 2 fb^{-1}, now plan 15 fb^{-1} for Run IIb.
- Improved Higgs sensitivity- add inner layer, increase lever arm for better impact parameter measurement w.r.t current detector.

- FEATURES of new detector
  - Keep it simple: single-sided sensors, no pitch adapters, minimal number of parts types
  - Complete replacement
  - Barrels only, no disks- concentrate on high PT physics
  - New SVX4 readout chip
  - Target late 2005

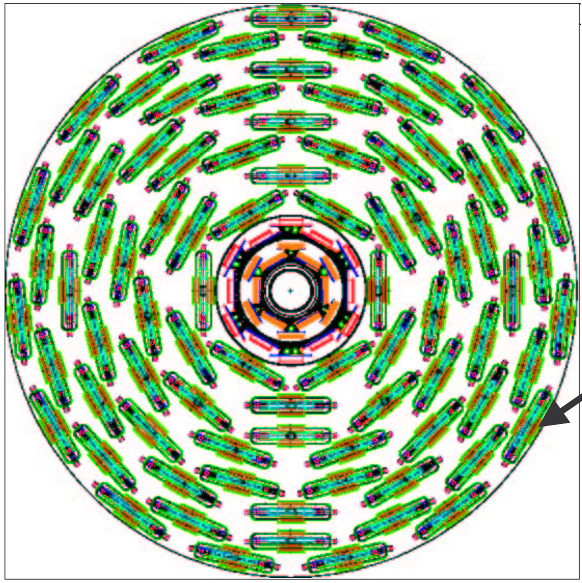
NEW



Detector Design

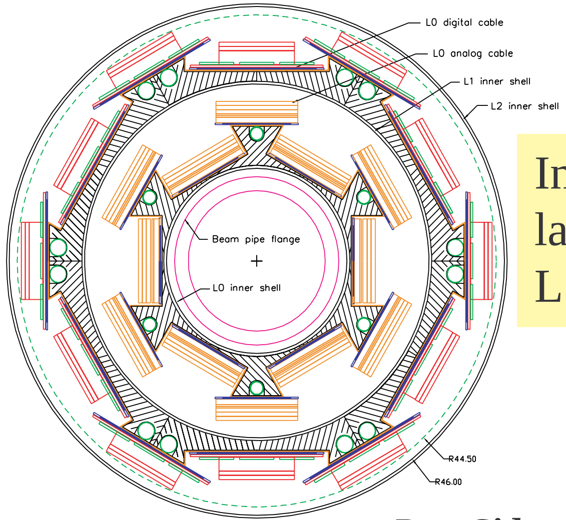


Plan view. Built in two sections, meet at z=0. Insert 6 silicon layers inside of central fiber tracker (18 planes of scintillating fiber).



Section view.

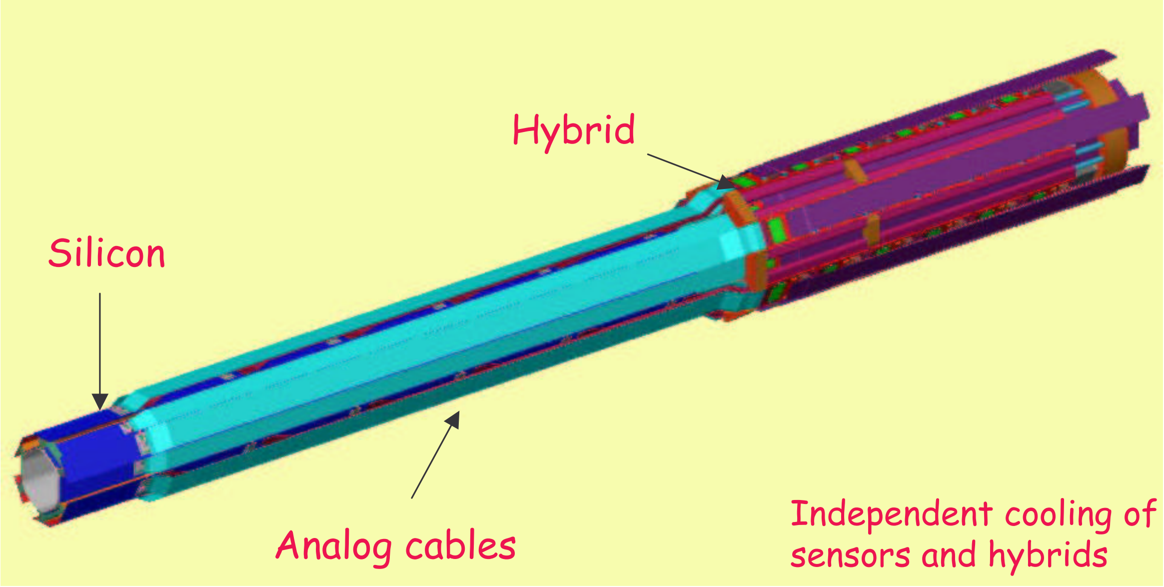
Stave



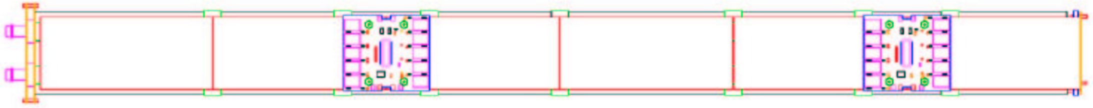
Innermost layers L0, L1

Layer 0 and Layer 1

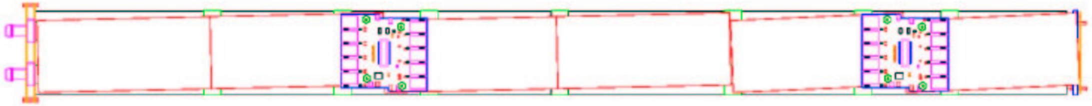
- Layer 0 and 1
  - Tight space, not supported by beam tube.
  - Minimize material
  - Cool to -10 ^{o}C to increase sensor lifetime
  - No hybrids mounted on sensors for L0: analog cables



Staves (Layers 2-5)

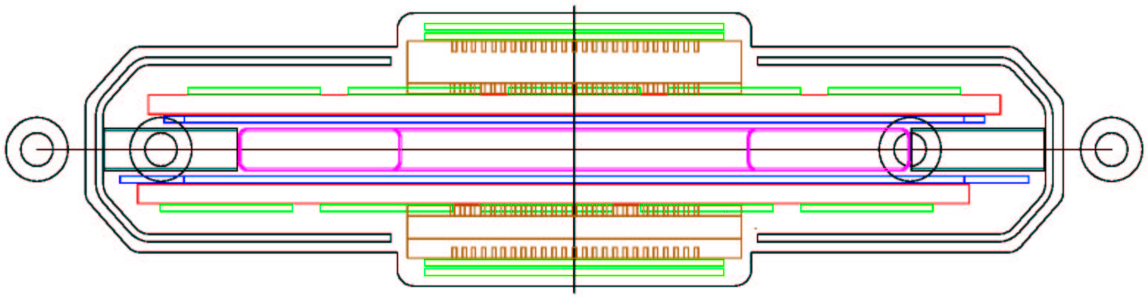


Axial



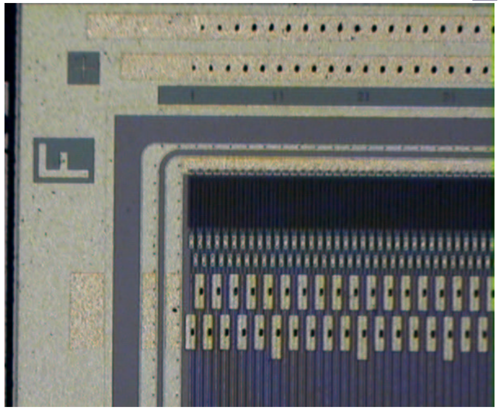
Stereo

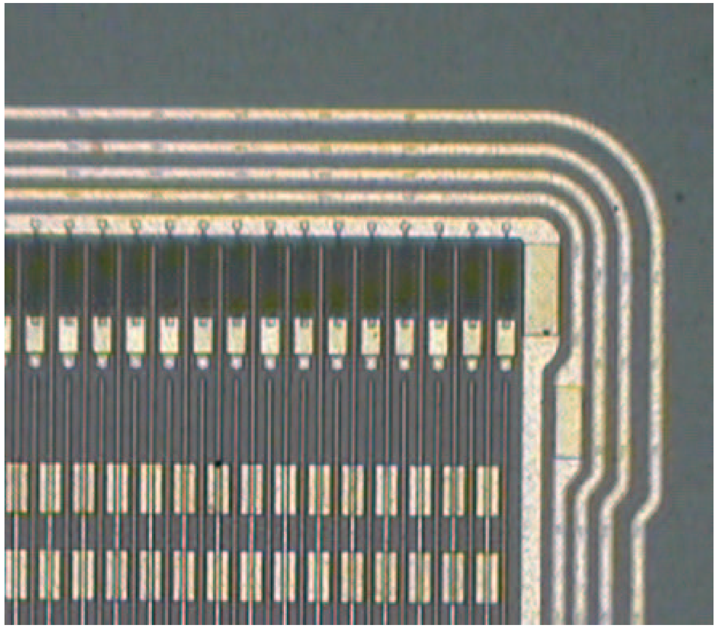
Module configuration for outer layer staves. Stereo angle is 1.24 or 2.48 deg.



Stave Cross Section (168 needed). Supported in bulkheads at z=0, 605mm

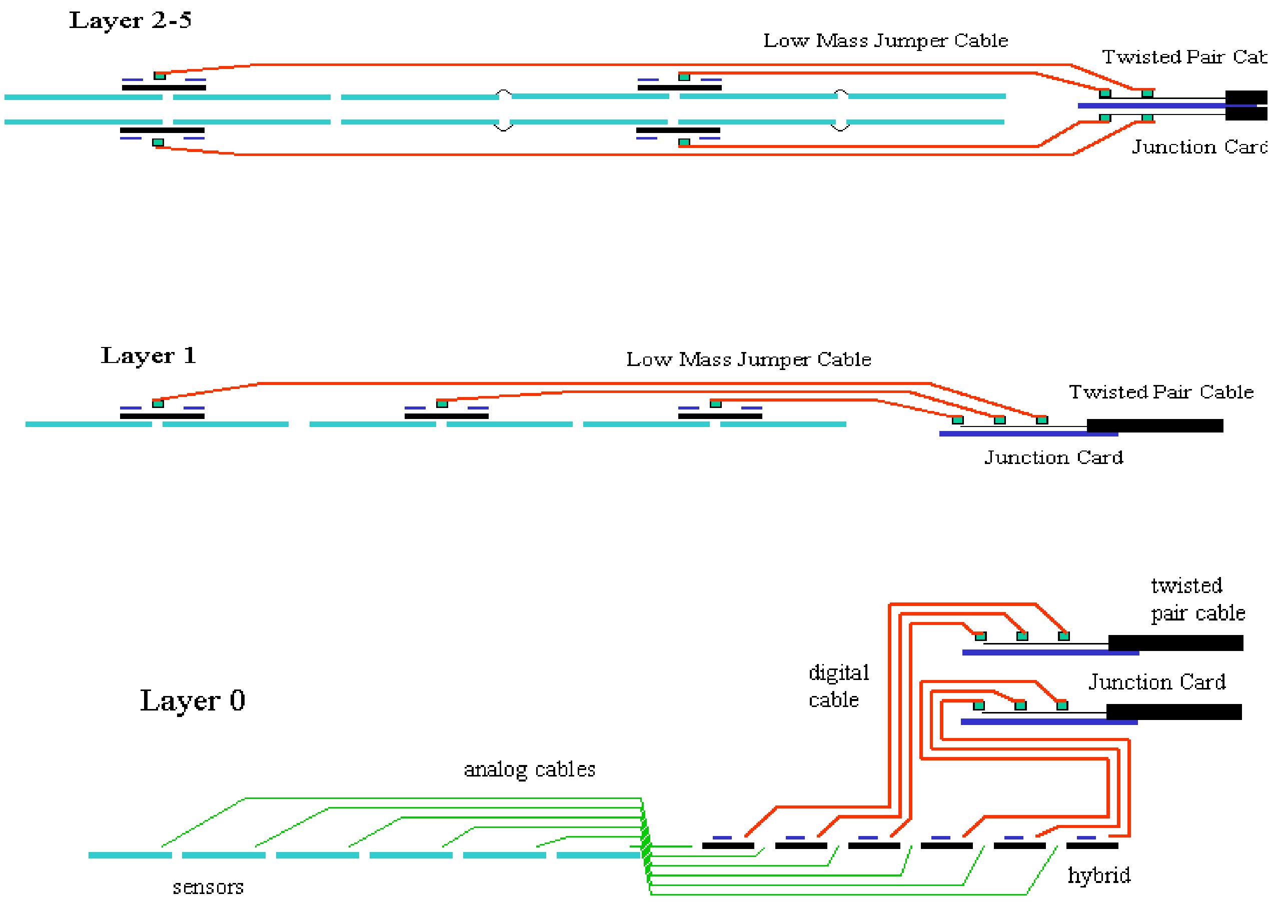
Inner sensors





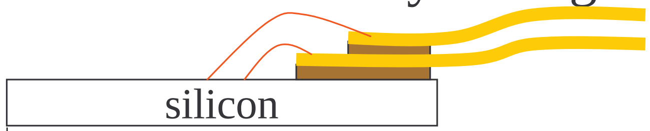
- Must be radiation-hard (up to 15 Mrad)
- Required: breakdown >700V, depletion < 300v.
- Pitch
  - 50 μm, L0
  - 58 μm, L1
- <u>Photos</u>: Detail of Hamamatsu (upper) and ELMA (lower) prototype sensors for the inner layers. Note the differing guard ring structure.

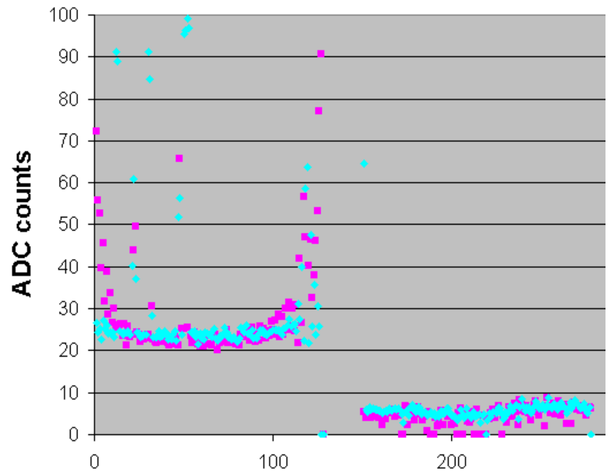
Front-end Readout Cables

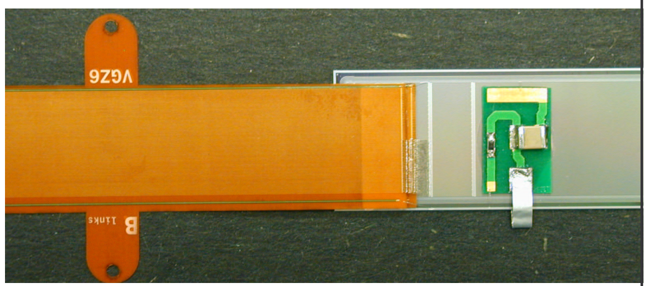


Analog Flex Cables

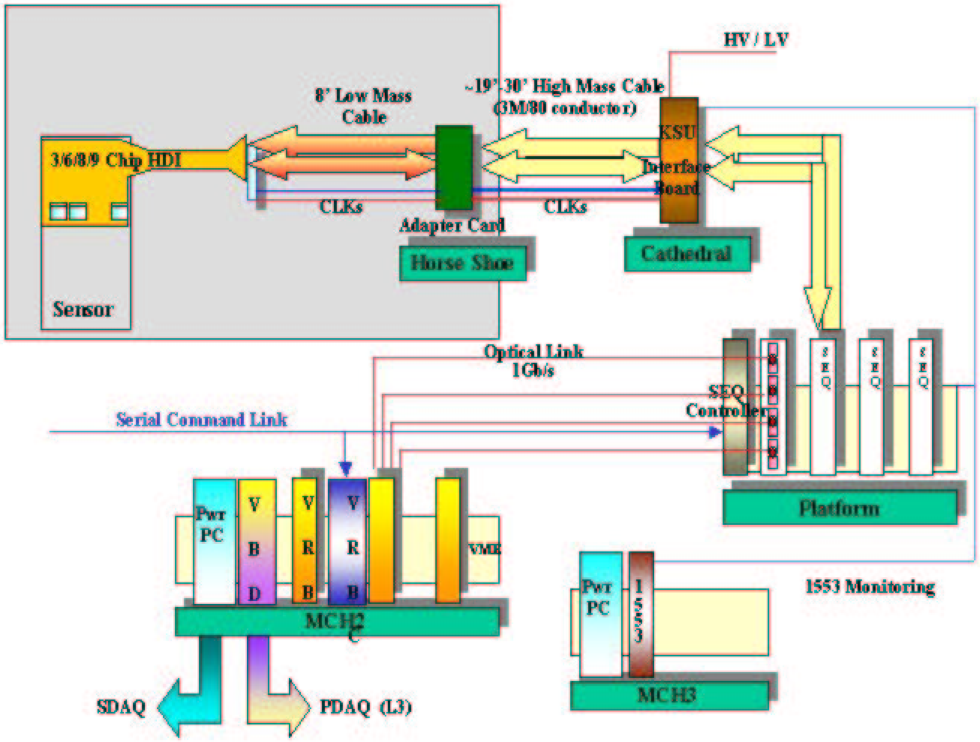
- For layer 0 need low mass, fine pitch, flex cables to carry analog signals to hybrids
  - Technically stimulating
    - **Trace width ~** 15 - 20 **μm, pitch 91 μm**
    - **2 cables offset by 50 μm**
  - Noise determined by capacitance
    - For S/N > 10: **C < 0.55 pF/cm**
    - current design, with 16mm trace width -> 0.32 pF/cm
- Prototype cables (Dyconex)
  - First batch: 10/12 cables good.
    - Two had 2 open/shorts
  - Second batch: 25/ 27 cables
    - Two with ≥ 2 open/short
  - Cables laminated and bonded
- Shielding needed -
  - Cable is antenna for RF





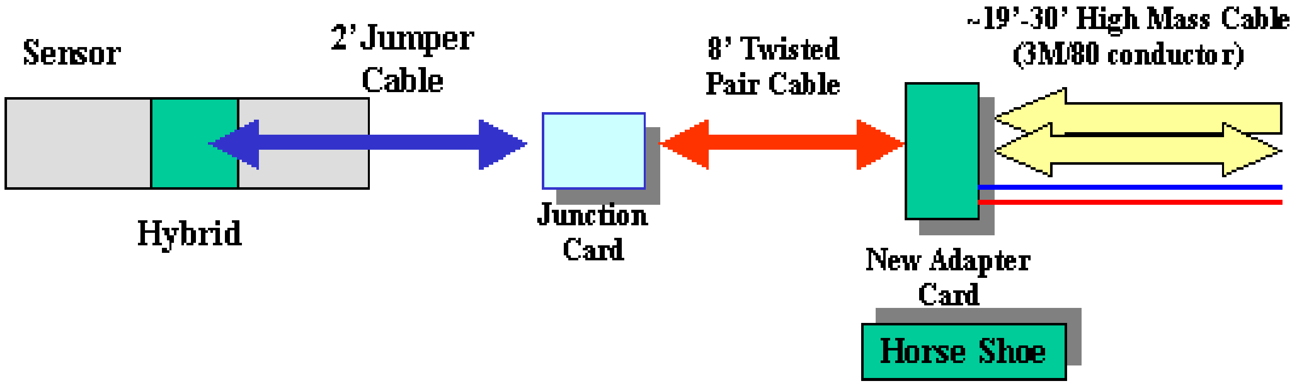


Changes to readout



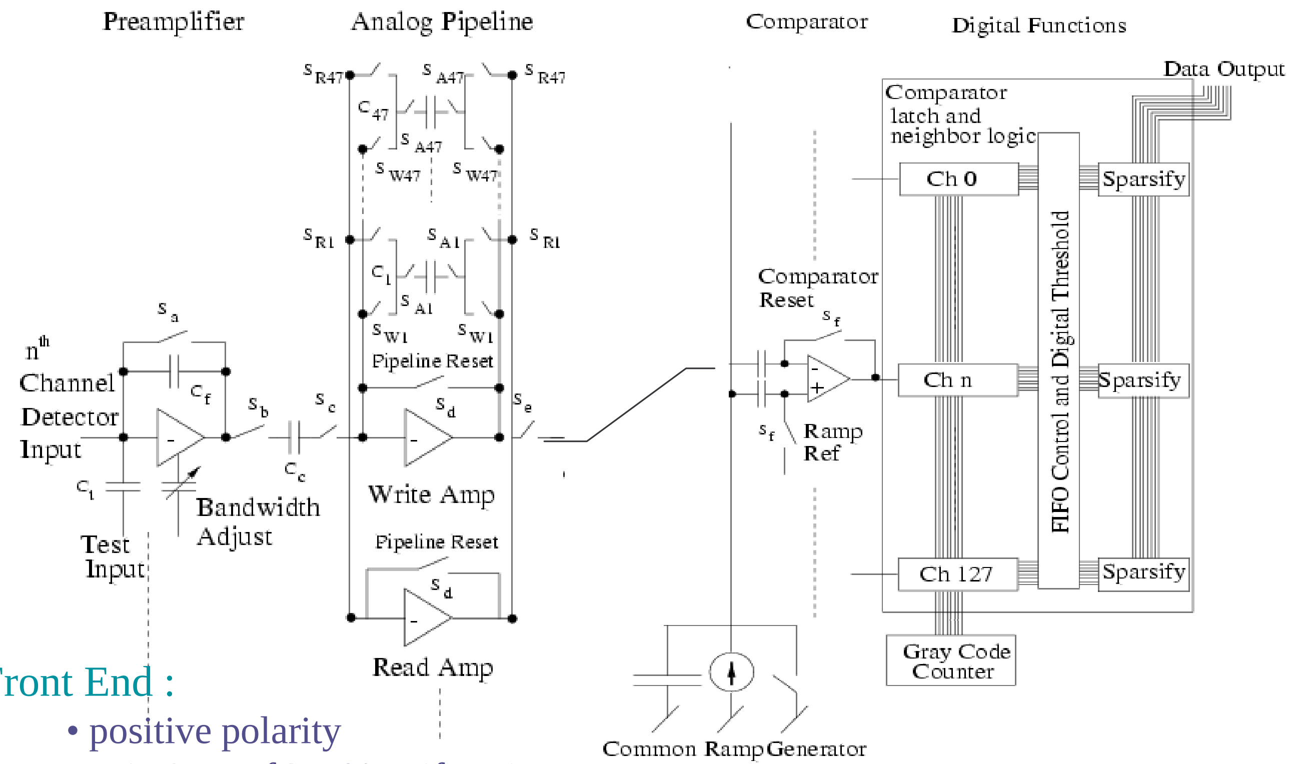
- Area in gray is replaced..
- Recycle most cables, and all downstream electronics.

New Front End



- Ceramic hybrid with new SVX4 readout ICs.
- Flex Jumper cable 50-100cm long.
- Passive Junction card - solder twisted pair at one end
- Plug twisted pair plus clocks into active adapter card

SVX4 Chip



Front End :

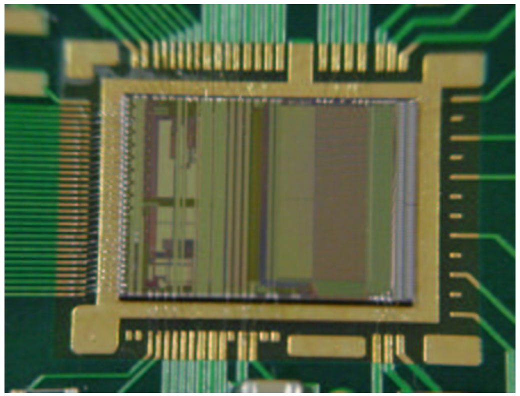
- positive polarity
- gain 3 mV/fC, 5% uniformity
- load 10 – 40 pF
- risetime 60-100 nsec
- dynamic range 200 fC
- ‘black hole’ clumping
- reset time 200 nsec
- pipeline 42 cells

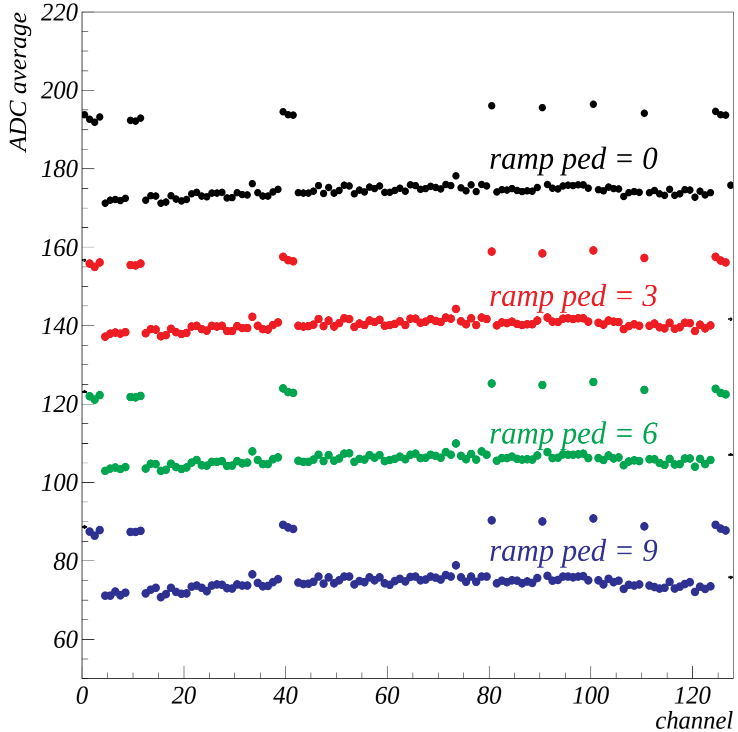
Back End :

- Wilkinson ADC, 106 MHz counter
- dynamic pedestal subtraction
- data sparsification
- neighbor logic
- differential output drivers upto 17 mA
- configuration register

SVX4 chips

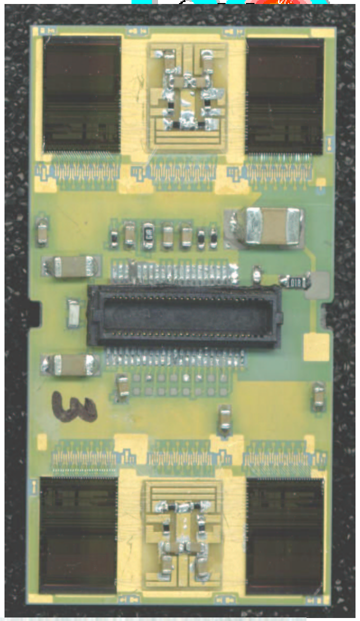
- Design effort began (11/00)
- Joint effort of Fermilab, LBL, Padua
- Prototypes delivered in 6/02
  - Works in DØ and CDF modes
  - Known fixes, more tests to do
  - 2^{nd} proto submission 1/03
- DØ involved early in testing. Main problem to fix is non-uniform pedestal.

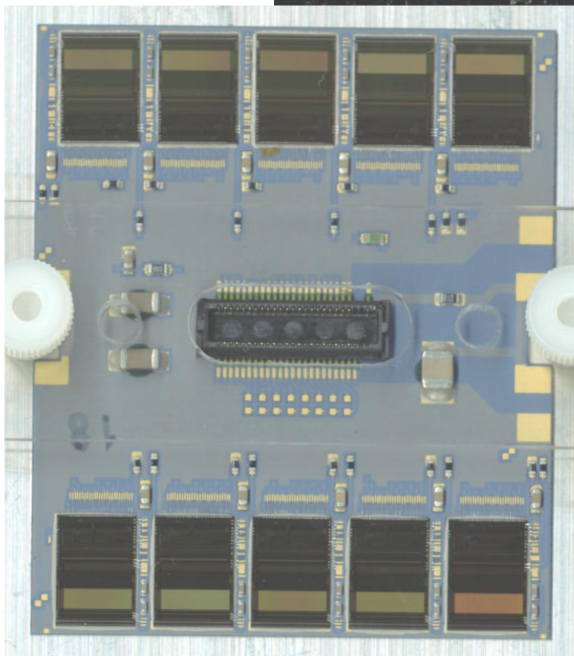


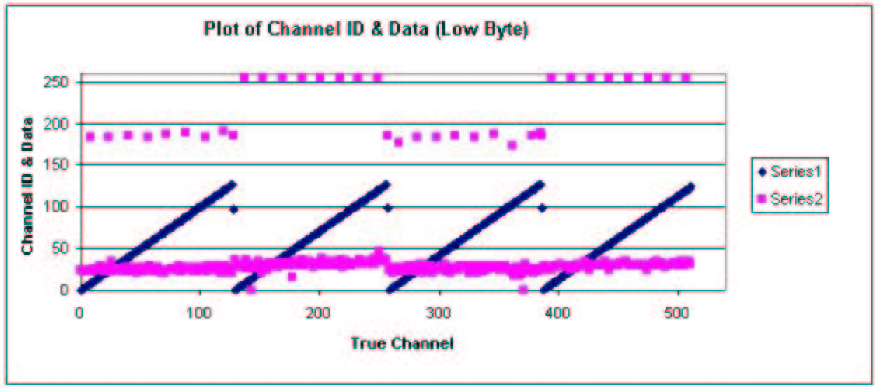


Hybrids

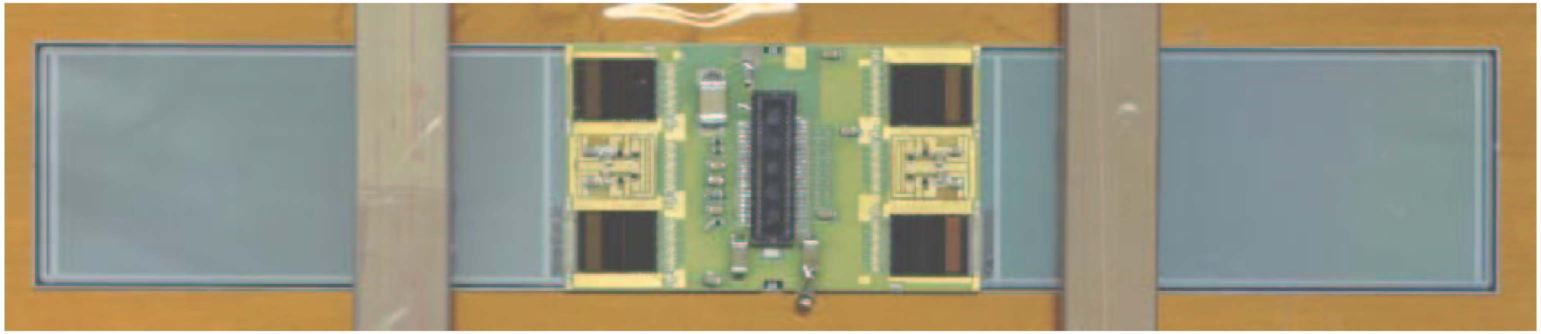
- Double ended readout
- Prototypes exist and work for L1 and L2-3
- Important to work with vendors from the start (CPT, Amitron)
- Commercial stuffing

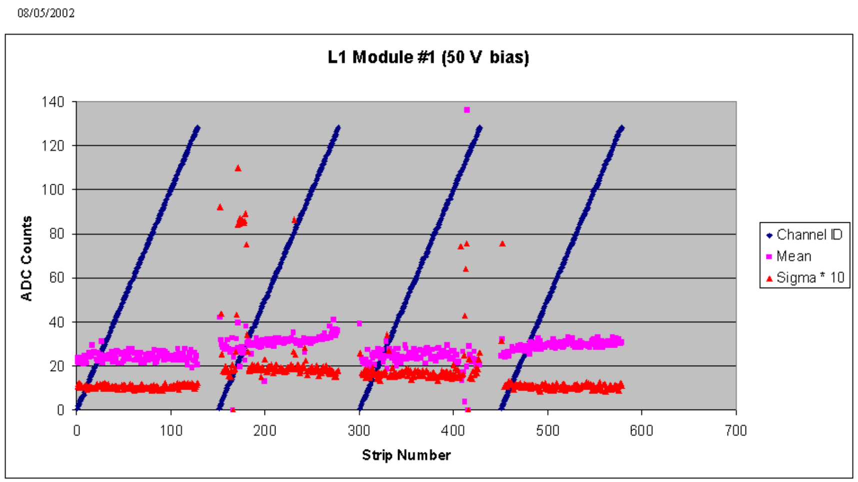






Prototype L1 Module





- Two L1 ELMA sensors
- L1 prototype hybrid (stuff 4/6 SVX4 chips)
- It works!

Conclusion

- Simulations show new design increases Higgs efficiency ~40% relative to current setup. More luminosity buys x7.
- Design, prototyping, and costing are in good shape. Reviews have been very positive.
- Waiting DOE final approval in Dec ’02.
- Aggressive schedule aims for late ’05 installation.

Contributions

- Sensor Testing
  - Kansas State, SUNY StonyBrook, CINVESTAV, Moscow State
- Readout Electronics
  - FNAL, Kansas State, Kansas, UIC, Fresno State, Brown, Louisiana Tech, Northwestern, Zurich
- Mechanical Design and Fabrication
  - FNAL, Washington, Michigan State
- Monitoring
  - NIKHEF, Rice
- Funding: 131 FTE-years; cost ~$13M + conting.; DOE + NSF MRI